PRELIMINARY RESEARCH PROPOSAL (COE) (FY05)

TITLE: A study to estimate salmonid survival through the Columbia River estuary using acoustic tags

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DURATION OF PROJECT: 2001 to 2008

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PROJECT SUMMARY

The goal of this study is to use a newly developed acoustic tag and concomitant detection arrays to estimate survival, residence behavior, and ocean-entry timing of both stream- and ocean-type juvenile salmonids through the lower Columbia River and Columbia River estuary. Information gained from these efforts will be used to explore mechanisms of hydropower system

delayed mortality, characterize how salmonids utilize estuarine habitats, and evaluate the affect from physical changes to the estuary (flow and habitat) on the recovery of listed salmon stocks. We propose to implant micro-acoustic tags into PIT-tagged juvenile salmon obtained at the Bonneville Dam smolt monitoring facility. Target tagging groups will be selected using the divert-by-code system to answer management and recovery questions through coordination with regional interests. These groups may be comprised of evolutionarily significant units (ESUs), rearing histories (hatchery versus wild), or hydropower system passage histories (transported versus in-river, multiple bypass). A key study element has been the development of an acoustic tag small enough for use in subyearling fall chinook salmon *Oncorhynchus tshawytscha*. Using "downsized" tag hardware, a wider variety of targeted groups and life histories can be evaluated to develop a broader understanding of the relationship among the hydropower system passage experience, estuarine residence, and survival.

Use of known-source PIT-tagged fish is a powerful tool that enables behavioral and survival observations in the estuary to be linked to the ESU, rearing type, and passage history through the hydropower system. As the use of this technology matures, target groups will be selected based on coordination between National Marine Fisheries Service (NOAA Fisheries), COE, and regional managers regarding which groups best represent the management questions of interest to the region. If necessary, the target groups will be marked by others or by NOAA Fisheries to establish the population sizes required for sampling at Bonneville Dam.

The overall study has been developed along three tracks. First, in 2001, we evaluated the feasibility of reducing tag size and designing a detection array based on modeling the physical (vertical profile characteristics of temperature and salinity over various river flow conditions) and acoustic (transmission losses given the bathymetry characteristics of the basin and the ambient noise spectra) environments of the lower river. Second, in 2002 through 2004, we constructed prototype detection arrays and tested deployment and detection characteristics using live tags, prototype detection array nodes, and releases of fish acoustically-tagged from Bonneville Dam using partially populated primary and secondary arrays. Finally, in 2005 and future years, we propose to implement full-scale survival evaluations using the tags and detection array tools developed during the initial years. Sample sizes for this work will be determined based on criteria of the proposed evaluation, single-release survival model requirements, and tag detection probability estimates. This step-wise approach and concern for potential biological effects is modeled after the approach taken by NOAA Fisheries to successfully develop the passive integrated transponder (PIT) tag and PIT-tag detection systems.

Specific objectives for 2005 are to 1) evaluate run-of-the-river yearling chinook salmon survival through the lower Columbia River and its estuary using fully-populated primary and secondary detection arrays, and 2) evaluate run-of-the-river subyearling chinook salmon survival through the lower Columbia River and its estuary using fully populated primary and secondary detection arrays.

BACKGROUND

General

Mortality in the estuary and ocean comprises a significant portion of the overall mortality experienced by salmon throughout their life cycle, and seasonal and annual fluctuations in salmonid mortality these environments are a significant source of recruitment variability

(Bradford 1995). In recognition of the potentially important contribution of estuaries to overall survival, recent studies attempted to evaluate effects of estuarine conditions on salmon. Simenstad et al. (1992) suggest that estuaries offer salmonids three primary advantages: productive foraging, relative refuge from predators, and a physically intermediate environment in which the fish can transition from freshwater to marine physiological control systems. Thorpe (1994) reviewed information from three genera of salmonids (*Oncorhynchus, Salmo,* and *Salvelinus*) and concluded that salmonids are characterized by their developmental flexibility and display a number of patterns in estuarine behavior. He found that stream-type salmon migrants (some chinook, coho, sockeye, and Atlantic salmon) move through estuaries and out to sea quickly, compared to ocean-type salmon migrants.

Most of our knowledge of how salmonids utilize estuaries is limited to smaller systems that can be more readily sampled. For example, Beamer et al. (1999) assessed the potential benefits of different habitat restoration projects on the productivity of ocean-type chinook salmon in the Skagit River, Washington. They concluded that restoration of freshwater habitats (peak flow and sediment supply) to "functioning" levels "would provide limited benefits unless estuary capacity or whatever factor that limits survival from freshwater smolt to estuary smolt is also increased." They used productivity and capacity parameters to estimate that estuarine habitat restoration could produce up to 21,916 smolts/ha. Reimers (1973) found a diverse number of estuary rearing periods and strategies for fall chinook salmon in the Sixes River, Oregon.

Columbia River

Little information is available describing historical use of the Columbia River estuary.

Rich (1920) found that 36% of the juvenile yearling and subyearling chinook salmon collected from 1914 to 1916 demonstrated extensive rearing in the estuary. As many as 70% of the fish sampled during July had resided in the estuary from 2 to 6 weeks (Jen Burke, Oregon Department of Fish and Wildlife, Pers. commun., June 2000). Subyearling chinook salmon attained 20 to 66% of their fork length (FL) while in the estuary. In contrast, in more recent times where hatchery fish dominate the juvenile population, Dawley et al. (1985) noted that movement rates through the estuary were similar to rates from the release site to the estuary, indicating limited use of the estuary by juvenile salmonids originating upstream from Jones Beach. Schreck and Stahl (1998) found mean migration speed of radio-tagged yearling chinook salmon was highly correlated with river discharge, and averaged approximately 2 mph from Bonneville Dam to near the mouth of the Columbia River. Movement in the lower estuary was influenced by tidal cycles, with individuals moving downstream on the ebb tide and holding or moving upstream during the flood tide. They reported a high proportion of tagged animals were lost to piscivorous bird colonies located on dredge disposal islands. Ledgerwood et al. (1999) also found that travel speed of PIT-tagged fish from Bonneville Dam to Jones Beach was highly correlated with total river flow. They observed significant differences in passages times at Jones Beach for spring/summer chinook salmon PIT tagged and released at Lower Granite Dam to migrate in-river, and fish transported to below Bonneville Dam and released. PIT-tagged fish detected at Bonneville Dam had significantly faster travel speeds than those released from a transportation barge below Bonneville Dam--98 and 73 km/day, respectively. These recent studies provide a cursory assessment of estuarine migration behavior.

Potential Effects of the Federal Columbia River Power System (FCRPS)

Physical processes in the estuary and thus estuarine habitat are shaped by two dominant factors, channel bathymetry and flow. River flow is controlled by climate variation and anthropogenic effects such as water storage, irrigation, withdrawals, and flow regulation. The FCRPS has altered the hydrology of the Columbia River estuary through flow regulation, timing of water withdrawals, and irrigation, which have affected the average flow volumes, timing, and sediment discharge (Bottom et al. 2001, NRC 1996; Sherwood et al. 1990; Simenstad et al. 1992; Weitkamp 1994). Annual spring freshet flows are approximately 50% of historical levels and total sediment discharge is roughly one-third of levels measured in the 19^{th} century. The direct effects of these changes to the estuary from FCRPS operations on salmonids have not been estimated.

The potential for delayed mortality on fish that migrate through the hydropower system is also a concern to fisheries managers and regional decision makers. Recent quantitative model studies have assessed the importance of survival downstream from Bonneville Dam to the overall life cycle, and sensitivity analyses identified the life stages where management actions have the greatest potential to influence annual rates of population change, and priorities for research (NMFS 2000a). A reduction in mortality in the estuary/ocean and during the first year of life had the greatest effect on population growth rates for all spring/summer chinook salmon stocks when a 10% reduction in mortality in each life stage was modeled. Use of smolt-to-adult ratios (SAR) calculated by the Plan for Testing and Analyzing Hypotheses (PATH) in the sensitivity analysis produced similar results.

These analyses suggested that salmonid recovery efforts will require an understanding of the important linkages between physical and biological conditions in the Columbia River estuary and salmonid survival. Kareiva et al. (2000) concluded that modest reductions in estuarine mortality, when combined with reductions in mortality during the first year of life, would reverse current population declines of spring/summer chinook salmon. Emmett and Schiewe (1997) concluded that survival must be separated between the freshwater, estuarine, and ocean phases in order to answer these management questions. Given the high proportion of mortality occurring below Bonneville Dam, the potential positive response in population growth rates from changes to survival in this area, and the uncertainty over the causal mechanisms of hydropower system delayed mortality, detailed studies of survival and behavior in the estuary are warranted.

Technical Basis

The proposed approach (to mark salmonid smolts with acoustic tags and track them through estuarine environments) has been successfully used in other applications. For example, Atlantic salmon marine acoustic-tagging project (MAP) has marked, released, and tracked Atlantic salmon *(Salmo salar)* smolts leaving several rivers in the Passamaquoddy Bay and the Bay of Fundy in southwestern New Brunswick, Canada (Gilles Lacroix, Department of Fisheries and Oceans, St. Andrews New Brusnwick, Canada, Pers. commun., December 2000). Both wild and hatchery-reared smolts were tagged and released. Automated receivers were strategically deployed underwater to form detection arrays or screens that monitored all fish leaving the river, the coastal zone in a 10 km radius of the river mouth, and movement across a 50 km stretch between the inner and outer portions of the Bay of Fundy. All tagged post-smolts were detected, survival was estimated, and the movements of some individuals were monitored for up to 3 months. Information obtained from the tracking included timing, location and rate of departure from the bay and return, travel direction, behavior and movement in relation to environmental conditions, and detailed tracks of individuals and group movements. The Bay of Fundy has up to 50 foot tides which produces a more uniform acoustic environment (due to the mixing of salt and fresh water) than we expect to encounter at the mouth of the Columbia River. However, these studies show that acoustic technology can be used to estimate survival and observe smolt behavior in salt water environments.

In the current application work, extensive modeling was conducted during the first year to determine the feasibility of using acoustic technology in the Columbia River estuary. The modeling and subsequent validation sampling suggested that detection ranges up to 300 yd (275 m) would be theoretically possible using a 150 dB source transmitter. In preliminary field trials using live implantable prototype fish tags and a bottom-mounted receiver designed for use in the Columbia River estuary, we have demonstrated reception and decoding capability to over 500 ft (150 m), indicating that acoustic technology is a practical tool for use in making robust survival estimates in this environment.

Summary

This study will allow assessments of salmonid migrational behavior and survival through the Columbia River estuary under current hydropower system flow management scenarios and the existing physical configuration of the estuary. High detection probabilities for fish implanted with small acoustic tags will allow the methodology to be applied to management questions important to the region. These include determining whether hydropower system delayed mortality can be measured in the reach between Bonneville Dam and the mouth of the Columbia River, characterizing how smolts use the estuary and whether estuarine habitat restoration actions influence habitat selection and survival, how salmonid behavior in the estuary varies between years, dominant environmental conditions (such as river flow), ESU, rearing type, and migration history.

The use of known-source PIT-tagged fish that are diverted by code at Bonneville Dam and outfitted with acoustic transmitters provides the opportunity to study how migrant salmonids from various ESUs and migration histories survive and behave in the estuary. While we expect to see constant migration rates and little actual rearing in the estuarine habitats by stream-type juvenile salmonids, this should be documented for all ESUs and estuarine use characterized in order to understand how yearling migrants currently behave and survive through the lower river. Little of the historic information is useful under current flow regimes, hatchery dominated populations, and the physical configuration of the estuary at it exists today. We expect to see increased diversity in habitat utilization and migration behaviors for ocean-type juvenile salmonids.

Estimating survival rates for the reach below Bonneville Dam is an important first step toward developing an understanding of whether delayed mortality occurs between Bonneville Dam and the mouth of the Columbia River and the magnitude and variability of the mortality. Survival can then be related back to the ESU, rearing history, and migrational experience (transported, in-river, multiply bypassed, etc.) We propose to address both through the research discussed below. A potential third step, outside the scope of this proposal, is to experimentally manipulate the hydropower system or salmonid passage experience and evaluate these effects on survival through the estuary.

This research complements current studies by NOAA Fisheries to evaluate effects of bypass systems on delayed mortality. The current micro-acoustic tag allows tracking of smolts for up to 30 days under field conditions to evaluate whether mortality occurs in a reach of the river where measurement is possible. If the delayed mortality is measurable between Bonneville Dam and the mouth of the Columbia River using the acoustic tag, experiments could be designed to evaluate the relationships between changes to the hydropower system and survival.

APPROACH

Our general approach has been to integrate the three main components of the program (tag signal specifications, receiver array design, and detection probabilities required by the single-release model) to provide maximum detection capability. In 2001, we contracted systems engineering firms to design the acoustic tag and a primary detection array based on acoustic model simulations and analyses of trade-offs between acoustic tag output characteristics (signal frequency, repetition rate and source amplitude) and probability of detection required by the single-release model, array location, environmental conditions, and constraints from the experimental design (sample sizes available and estimated survival to the mouth).

A prototype tag was produced for coating biocompatibility and acoustic reception trials beginning in September 2002, and more exhaustive biological compatibility evaluations were carried out in 2003. The original prototype has undergone improvement to maximize capabilities of the final product. Though still under development, the current tag is smaller than most electronic transmitter tags, measuring 20 mm long, 5 mm wide and tapering from 4 mm to 2 mm high. This is larger than target dimensions; however, weight of the current model is about 0.65 g, which is less than the design goal of 0.7 g dry weight. Ergonomic shape of the tag has also been improved. The encoding method currently being tested will provide for the possibility of over 64,000 individual tag codes. The encoding strategy allows for consideration of expanded capabilities being addressed, such as the addition of a pressure transducer to encode depth information in the transmitted signal.

From 2002 through 2004, we also tested a functional prototype detection node and demonstrated our capability to physically deploy, anchor, and retrieve fixed and autonomous detection arrays in the lower Columbia River estuary.

This stepwise process has proven invaluable in evaluating integrated system function (transmitter to receiver compatibility, factors affecting signal reception range, cable interfacing, deployment and retrieval techniques, anchor design) and for assessing software function and suitability. For example, as a direct result of our experience at Jones Beach using a prototype anchoring system, we specified and engineered an anchor design to resist burial while holding detection array elements in position during tidal cycles and high river flow events. This anchor was used to successfully secure a three-element demonstration array for over two months without shifting position or burial. The gradational process has also helped identify design defects before they were incorporated into a production system. As an example, during a cost-reduction analysis completed in late 2003, receiver-node hydrophone, software, and electronics were simplified, effecting a substantial per-node cost reduction. Resulting node electronics, cabling, communication, power supply, and software modifications functioned well. However, subsequent testing over the 2004 spring outmigration using acoustically tagged migrant yearling chinook salmon smolts revealed that sensitivity of the new omni-directional hydrophone/preamplifier assembly obtained from the primary vendor was inadequate to make detections. A replacement hydrophone from another vendor has been identified, and testing indicates an appreciable gain in range should be possible using the alternative unit. Final range and functionality evaluations for the redesigned cabled array nodes are scheduled for completion before the end of August 2004.

By the end of FY 2004, we will have completed intermediate steps between the design work initiated in 2001 and full deployment. With design work and initial testing essentially completed, the goal of using this tool to assess survival can be initiated. Two objectives have been developed for implementation during FY05 to step from the design and initial field test work to full implementation.

Objective 1

Evaluate run-of-the-river yearling chinook salmon survival through the lower Columbia River and Columbia River estuary using fully populated primary and secondary detection arrays.

Over the next several years, we propose to estimate juvenile salmonid survival from release at Bonneville Dam to the mouth of the Columbia River. In 2005, we will obtain generalized survival values for run-of-the-river (ROR) yearling chinook salmon passing Bonneville Dam. For this study, we will estimate survival to a primary detection array located near the mouth of the Columbia River estuary, at approximately river kilometer 9. In subsequent years, we will expand this effort by targeting groups of interest to regional managers.

The most favorable transect for a primary detection array was selected during system design and feasibility studies conducted in 2001 and secondary array locations have been identified to accommodate assumptions of the single-release survival model (Fig 1). Partial arrays were deployed near the proposed transects during a proof of concept demonstration in 2004 and, using data from the nine nodes recovered for inclusion in the analysis, both arrays intercepted a substantial portion of the tagged outmigrant population. Fish from each of the four groups released in 2004 were detected on each node interrogated as of this writing, indicating that fully populated arrays located along the proposed transects should maximize detection potential. Addition of information from interrogation of the remaining nodes will be accomplished by the end of August 2004.

The primary (fixed) detection array will be bottom-mounted and cabled to shore stations for near real-time data transfer and power transmission. Since nodes cannot be safely placed in the

Figure 1. Proposed primary and secondary detection array transects to be used to estimate juvenile salmonid survival using micro-acoustic transmitter tags. The primary array will consist of 24 bottom mounted nodes cable to shore for power and real-time data transmission. The secondary array will be comprised of 18 autonomous nodes suspended approximately 4.5 m from the bottom.

shipping channel, the primary array will be composed of two smaller, independent sub-arrays to cover the line from West Sand Island to Clatsop Spit. Based on current information for detection ranges for these nodes, the northern sub-array will be consist of twenty nodes running from West Sand Island (46\ 15.889' N, 124\ 00.258' W) south to the northeast side of the shipping channel along the Lower Desdemona Shoal Navigation Range (46\ 14.310' N, 123\ 59.442' W). The second sub-array will be comprised of four nodes extending in a straight transect east from Clatsop Spit (46\ 14.025' N, 123\ 59.866' W) to the southwest side of the shipping channel (46\ 14.245' N, 123\ 59.546' W), terminating directly across from the south end of the northern sub-array. The distance across the shipping channel at this point is approximately 650 ft.

The measured range for the replacement fixed array hydrophones will be evaluated during August 2004. However, preliminary tests of those units indicate that 450 to 500 ft of spacing between deployed nodes would be a conservative estimate to ensure that transmitters passing between nodes are detected. With a pulse repetition interval (PRI) of 5 seconds, this stationing will allow at least 9 pulses to be transmitted as the transmitter crosses the detection array reception range in a 11 km/h (6 knot) current. Overlap in range of the fixed sub-array end nodes across the navigation channel will provide detection of a minimum of 5 pulses for tagged fish migrating along the channel between the two arrays at 11 km/h.

A secondary detection array, downstream from the primary array, will be needed to satisfy the requirements of a single release survival estimation. For this study, the secondary array will consist of 18 autonomous nodes deployed on the Columbia River bar between U.S. Coast Guard Navigation Buoys 8 and 10 (Fig 1). These nodes are individual, self-contained units suspended approximately 4.5 m (15 ft) above the bottom on an anchored tether. Acoustic releases allow periodic recovery for battery replacement and data retrieval. Work in 2004 identified problems with anchors and acoustic releases being buried in the moving sand dune formations on the river bed (sand waves up to 2 m high) as well as entanglement in commercial crabbing equipment. Deployments in 2005 will utilize highly visible buoys on the surface to facilitate retrieval and reduce the likelihood of entanglement.

Twelve of the secondary-array nodes will be located on the Washington State side of the navigation channel and 6 on the Oregon State side of the channel along a straight transect from approximately 46\ 16.338' N, 124\ 04.258' W to 46\ 14.454 N, 124\ 03.375' W. Equidistant spacing will result in 425 to 450 ft intervals between autonomous nodes; however, exact locations will depend on several factors, including weather and sea conditions at time of deployment or the presence of crab gear. This spacing will provide detection capability similar to that for the primary array over the deployed area. Separation between north-south midpoints of the primary and secondary arrays will be approximately 5.3 km.

Secondary array nodes will be monitored and serviced as necessary to ensure data and power integrity over the tagged fish outmigration interval. We will regularly monitor the autonomous node locations to determine whether elements of the array have been moved. Nodes which have shifted from their original position will be redeployed to the proper station. If a node is not located, a replacement will be deployed. We will also recover autonomous nodes approximately every 28 days to replace batteries and data cards. Servicing dates will be coordinated with the tagged fish release schedule, travel times, and tide cycles to minimize missing tagged fish passing the array during servicing. Servicing will take approximately 20 to 45 minutes per node.

The geodetic position of each node in both arrays will be recorded at the time of deployment using coordinates obtained through the global positioning system (GPS).

As soon as nodes are in place we will conduct range tests to determine the static range of individual nodes. The mobile range tests will be conducted by towing an umbilical transmitter suspended from a buoy approximately astern of a vessel navigating slowly away from the recorded location of each node along a straight track. The transmitter will be towed to a distance of at least 600 feet from the node. For autonomous nodes, a GPS track with associated time stamps will be used to determine the position (range) along the tracks, and the clocks (node and GPS) will be synched by the time of the first detection of the umbilical transmitter. Nodes in the fixed array will be monitored during the process from their respective shore stations. This process will be repeated periodically during the field season to verify range continuity over the deployment period.

In addition to the mobile range testing, we will also install beacon tags within the arrays to serve as system function checks throughout the course of the sampling season.

Timing for deployment of the arrays will be subject to funding and fabrication schedules. To date, four of the fixed node assemblies forming the primary array have been fabricated. The remaining twenty nodes needed to begin making survival estimates in 2005 will require procurement of long-lead items to insure completion, system integration, and testing prior to delivery and deployment. A start date for this project is therefore heavily dependent on securing funding in time to complete this process.

An aggressive schedule should allow delivery and installation of both arrays by mid-April, in time for tagging the early ROR yearling chinook salmon outmigration passing Bonneville

Dam. However, we will make provision to begin tagging yearling chinook salmon as late as possible should delivery and installation be delayed.

Building on experience gained during the 2004 spring outmigration, all fish to be acoustically tagged will be captured using the Bonneville Dam Second Powerhouse Juvenile Fish Facility (JFF) daily smolt monitoring sample. Only hatchery-reared fish without PIT tags will be targeted for this study. Fish to be tagged will be separated from the daily sample on the day prior to the tagging date, and held on river water until the following day.

Tagging will be accomplished in a manner similar to that described by Adams et al. (1998) but modified to exclude the antenna procedure. Fish will be individually anesthetized with tricaine methanesulfonate (MS-222). While immobile, fish will be weighed and measured, and the PIT tag and acoustic tag codes associated with the fish will be recorded. The fish will be placed dorsal surface down on a foam operating table, and a continuous supply of anesthetic water will be supplied during surgery by a tube inserted into the mouth. A 10-mm incision will be made approximately 2 mm to the left of the mid-ventral line just anterior to the pelvic fin girdle. Since we expect to use PIT-tagged fish from the divert-by-code system at Bonneville Dam during future operations, a PIT tag will first be inserted through the incision. A functioning acoustic transmitter will then be inserted into the abdominal cavity. The incision will be closed by two interrupted sutures, and the fish will be placed in a bucket of fresh water for observation during recovery. Following recovery from anesthesia after surgery, all fish will be held for 24 h to evaluate short term tagging effects.

Sample Sizes and Study Design

Difficulty in recovering nodes from the 2004 deployment has delayed data analyses and attendant survival estimation and variance estimates for empirically deriving 2005 release group size requirements. Analysis and incorporation of data from nodes retrieved within the last few days may mitigate this problem. For the present, however, nothing in data examined to date indicates theoretical sample size estimates are invalid. For current planning, we will use the smallest predicted tagged fish group size estimates which will result in the required 0.10 precision based on assumed minimum probability of detection at the primary array of 0.60, survival to the primary array of 0.60, secondary array detection probability of 0.60, and survival between the primary and secondary arrays of 0.90. Using these parameters, a precision of approximately 0.094 can be realized using 250 fish per release group.

A total of 3,000 micro-acoustic tags will be available for estuary survival studies in 2005. Of these, 1,000 tags will be dedicated to yearling chinook salmon, and the remaining 2,000 will be used for subyearling smolts (Objective 2). We propose to tag four groups of up to 250 yearling chinook salmon during the spring outmigration period. From each tag group, up to 245 fish (release group) will be held overnight and released after approximately 24-h. All groups will be released into the JFF outfall pipe near the fish facility.

Five randomly selected fish (retention group) from each tag group will be retained for approximately 2 weeks after tagging, or until the fish expire. Held fish will be fed daily. At the end of the 2-week retention period, remaining fish will be sacrificed and necropsied to assess adhesion growth, encapsulation progression, abnormal organ development, and tag rejection.

We will use tags from these fish, along with tags from 24-h incidental release group mortalities, to assess acoustic tag longevity.

Sufficient numbers of fish should be available for tagging from 15 April through 27 May. We will begin tagging operations in 2005 on 15April, or as soon as deployment of primary and secondary arrays is completed and end on 27 May. The remaining two tagging dates will be spaced with an equal number of days between the start and end dates, providing the greatest possibility for survival comparisons between early and later run outmigrants over the time available. This tagging strategy also allows the most flexibility for a contracted tagging schedule. For example, if array deployment can be completed in time for tagging to begin on 15 April, release dates would be 14 days apart. If deployment is delayed until 6 May, release dates would be 7 days apart. Obviously, a very condensed schedule affords a more limited picture of overall yearling chinook salmon survival, and reduced timing contrast among release groups. Though even a very restricted release schedule of less than one week is logistically possible, survival data from this scenario would offer essentially a point estimate. A decision on whether to proceed with tagging after 6 May can be made based on the array deployment schedule.

We do not expect array delivery and installation to be so severely delayed as to require abandoning this objective. However, in the unlikely event that funding and delivery constraints do not permit timely execution, we will conserve resources and reserve the 1,000 tags allocated for this objective for use during 2006.

Objective 2

Evaluate run-of-the-river subyearling chinook salmon survival through the lower Columbia River and its estuary using fully populated primary and secondary detection arrays.

Since little is known about Columbia River subyearling chinook salmon life history in the estuary and early ocean life phases, the primary impetus driving the micro-acoustic tag development program was to produce a transmitter small enough for implant into the majority of subyearling chinook salmon passing Bonneville Dam. In fact, the tag life was specifically set at 30 d to accommodate increased travel time (compared to yearling smolts), and the possibility that some subyearling populations may use the estuary as nursery areas for extended periods prior to emigration to the ocean.

Though the current tag is slightly larger than original design parameters, dry and residual weights are sufficiently reduced to begin using this product for subyearling chinook salmon survival estimation. We have successfully implanted the previous version of this tag into subyearling smolts down to 100 mm fork length (FL) during biocompatibility evaluations in 2003 (McComas et al. In prep.) with no apparent deleterious effects. In addition, a recently concluded study conducted at PNNL in Richland, WA. has demonstrated a 30-d survival of subyearling chinook salmon as small as 76 mm FL implanted with the current tag (unpublished data). Details concerning growth, tag rejection, fish condition, and mortality will be available soon. However, gross examination of the data indicate that surviving fish experienced growth in length and weight and exhibited wound healing and tag encapsulation commensurate with that observed in larger fish under similar conditions. We will use these data to estimate the minimum acceptable length for tagged fish in 2005.

We propose to estimate subyearling chinook salmon survival from release at Bonneville Dam to the mouth of the Columbia River in FY05. We will obtain survival values for generalized ROR subyearling smolts passing Bonneville Dam by estimating survival to the primary detection array near the mouth of the Columbia River estuary described under Objective 1. In subsequent years, we will expand this effort by targeting groups of interest to regional managers.

We will tag up to 2,000 subyearling chinook salmon in 2005. Smolts to be acoustically tagged will be obtained from the Bonneville Dam Second Powerhouse JFF daily smolt monitoring sample. Only fish without PIT tags will be targeted for this study. Fish to be tagged will be separated from the daily sample on the day prior to the tagging date, and held on river water until the following day. Subsequent tagging, handling and release group and retention group sizes, and release and necropsy procedures will be similar to those described for yearling chinook salmon under Objective 1. Retention groups will be held for at least two weeks. However, subyearling chinook salmon smolts may experience a longer residence period in fresh water compared to yearling cohorts. To gain a better understanding of wound development and tag retention in release group fish over the fresh-water phase, retention fish may require a holding period longer than two weeks. The possibility of increased retention time will be re-examined based on emigration timing returns past the primary array for the initial release group.

Sample Sizes and Study Design

We proposed to tag up to 8 groups of subyearling chinook salmon over the course of the outmigration from mid-June through mid-August 2005. This will result in one release group per week. This strategy will produce the first reliable estimate of overall subyearling chinook salmon survival through the lower Columbia River downstream from Bonneville Dam. Successful release of all groups will also provide, at minimum, data for comparing survival and timing among various segments of the subyearling chinook salmon outmigration.

FISH REQUIREMENTS

FY 2005

Objective 1 - up to 1,000 hatchery propagated river-run yearling chinook salmon from the Columbia River watershed.

Objective 2 - up to 2,000 river-run subyearling chinook salmon from the Columbia River watershed.

FY 2006 - 2008

Large numbers of fish may be required during future implementation. The numbers of fish required for each target group will be determined dependent on estimated survival to the mouth obtained in 2005 and future years, variability about these estimates, detection probabilities, and requirements of the single-release model. Existing populations of PIT-tagged stream- and ocean-type migrants passing Bonneville Dam will be used to the fullest extent possible. The need for additional PIT tagging will be determined during annual planning stages, and will depend on which groups are selected for study, the number of PIT-tagged fish estimated to pass Bonneville Dam, and the numbers of those fish available for acoustic tagging.

SCHEDULES

We propose to conduct this work in two phases--design and feasibility followed by full implementation. Procurement delays and funding constraints have deferred full implementation for 1 year. FY04 is considered the final year of the design and feasibility phase of the effort. During the fifth year (2005), we will initiate full implementation by securing baseline survival and timing estimates for generalized yearling and subyearling chinook salmon. In future years, we will continue this effort by refining target groups to begin addressing specific management-related concerns.

It is important to consider this work in the context of environmental variability, since the importance of the estuarine environment may vary between years. Therefore, we will propose to implement the study over a number of years beginning in 2005.

IMPACTS TO PROJECTS, FACILITIES, AND EQUIPMENT

In 2005, use of existing space and facilities at the Bonneville Second Powerhouse Juvenile Smolt Monitoring Facility will be required for capture, tagging, and holding of acoustically-tagged fish. Access to river water and a commercial electrical power supply and space to park an acoustic tagging trailer will also be needed. We will coordinate with the Bonneville Dam Project, Smolt Monitoring Facility personnel, and other researchers to ensure our requirements for space and water fit within the needs of other user groups.

PROJECT PERSONNEL AND DUTIES

1. Project Leader–Lynn McComas, NOAA Fisheries
2. Project Leader and Tag design–Thomas Carlson, Battelle Pacific Northwest National Laboratories
3. Survival estimates–Steven G. Smith, NOAA Fisheries

TECHNOLOGY TRANSFER

Technology transfer will be in the form of written and oral research reports as required. Draft reports will be provided to the COE. Results will also be published in appropriate scientific journals and presented at scientific forums.

RELEVANCE

The NOAA Fisheries 2000 FCRPS Biological Opinion (NMFS 2000b) Research Action 47, stipulates that delayed mortality of transported versus non-transported be estimated. In Research Actions 158 through 160, the 2000 Biological Opinion also includes provision to identify, catalogue, mitigate, and restore factors in the Columbia River estuary limiting to salmonid survival. Research Actions 161 through 164 include provision for development and funding of a monitoring program aimed at evaluating the dynamics among the hydropower system, the estuarine environment, and fish response to changing conditions. Information from this study can be used to directly or indirectly address these actions.

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